a great surprise, because the species was not known to spend the winter months north of the equator. In March and April 2008 the adult eagles we tracked have so far not triggered their return migration. Whether the one year old eagles stay in Africa or return to the breeding grounds is another question which we hope to solve. Considerably more second-hatched young eagles must be hand-reared every year in order to ensure that the population remains sustainable. In 2008 18 more young eagles besides 5 adults are planned to be fitted with PTTs.

Technical development

As for our raptor studies the development of the technical side of satellite telemetry can be divided into three phases: the period during which only battery-powered transmitters with Doppler locations were available, the period during which solar-powered transmitters with Doppler locations were used, and finally the period during which transmitters with GPS locations could be employed.

Taking a middle-sized species such as the Osprey, in 1992-1995 we used battery-powered PTTs with Doppler locations. The PTT's life expectancy was about one year, when programmed to transmit for several hours every few days. We obtained a maximum of 100-150 locations from these PTTs. From 1995-2003 we used solar-powered PTTs with Doppler fixes for medium-sized raptors with a PTT life expectancy of several years (one case of 9 years) providing thousands of Argos locations per annum when sufficient light is available. Since 2004 we have used solar-powered PTTs with built-in GPS devices providing fixes precise to within a few dozen metres. These PTTs also furnish data on flight speed, direction and altitude to allow analysis of behaviour in detail for Ospreys and other similar-sized raptor species.

Depending on the size of the birds other PTTs are available. We used our first GPS PTT on an adult Imperial Eagle in 2003. Since 2007 we have used 22g GPS PTTs for Black and Red Kites. Very soon we hope to track three Hobby Falcons *Falco subbuteo* with tiny 5g PTTs, however with Doppler fixes.

Some highlights

Based on the monitoring of 146 individuals of 14 different species which we fitted with transmitters between 1992 and 2007 (see www.Raptor-Research.de for more information) we report here on a few highlights of our own telemetry results.

Year-round movements

One of our main objectives was to obtain a complete picture of the movements of adults throughout the year: the exact amount of time spent in the breeding sites, on migration and wintering. This was achieved for the first time in 1994-1995 for an adult male LSE tracked from northern Germany to its winter quarters in Zambia using a battery-powered PTT with Doppler fixes. This was the first detailed recording of this type for a European bird migrating to Africa. This eagle spent seven and a half weeks for each of its migrations over a distance of almost 9000 km. It flew a daily average of 166 km and its autumn and spring routes proved to be nearly identical. Its winter quarters in Zambia covered an area of 25,000 kms. We have succeeded in documenting the movements of other eagle species for at least one whole year, such as Steppe Eagles *Aquila nipalensis*, Greater Spotted Eagles *Aquila clanga* (GSE), Osprey, Honey Buzzard *Pernis apivorus*, Black and Red Kites *Milvus migrans* and *M. milvus*.

Thanks to solar-powered PTTs it has later been possible to compare the routes and time spent on several consecutive years. Satellite tracking of a pair of Lesser Spotted Eagles nesting in Germany yielded 3,641 locations in all. Four autumn and two spring migrations were recorded in full between 1997 and 1999. The two males' transmitters provided us with fixes over a period of about 24 months and that of the female 19 months.

The male took up its winter quarters in Zambia 9,300 km from its nest and the female 11,300 km in Zimbabwe, South Africa and Mozambique. She spent almost half the year on migration (47.6%) and only 9% wintering.

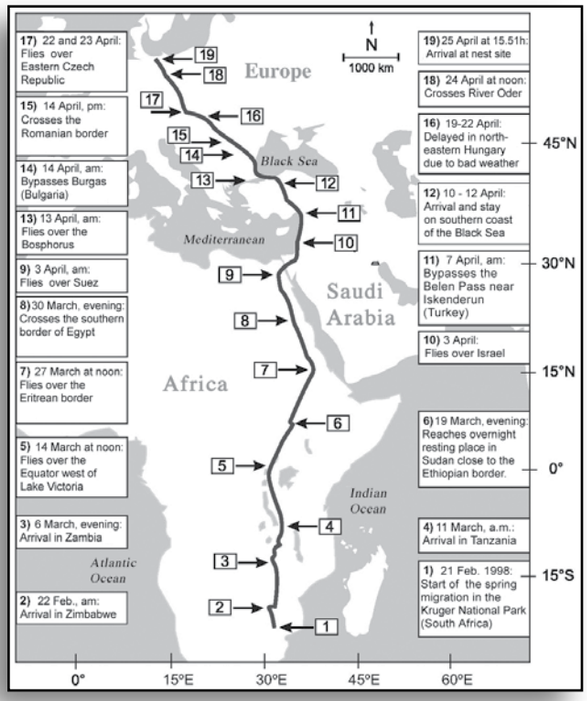

Fig. 1: The migration route of an adult Lesser Spotted Eagle female fitted with PTT 27999 from winter quarters in South Africa to breeding site in Germany with details of some of the passage points. Among the Doppler fixes were all night roosts along the 10,753 km long migration route which lasted 64 days.

The male devoted 35.1% of the year on migration and 21.1% wintering. The migrations lasted an average of 81 days (52-119 days), the autumn migrations being clearly longer (74-119 days) than those in spring (52-64 days). The speed of migration varied not only from year to year but also according to the regions crossed. The longest stages were recorded during the crossing of the Sahara desert (up to 521 km a day), with the highest speed reaching 66.8 km/hr.

The complete spring migration route of the female LSE from winter quarters to breeding site, including all overnight stops, was documented in detail for the first time in 1998 using a solar-powered PTT with Doppler fixes. The female left its winter quarters in the Kruger National Park, South Africa, on 21 February 1998 and 64 days later, on 25 April, arrived late at the breeding site in Germany. During 51 days it covered on average 211 km (min. 18, max. 406 km/day) (see Fig. 1 above). The arrival of the female at the breeding site was observed directly. This enabled, for the first time, proof of a temporary partner change. The female (fitted with a transmitter) from the previous year immediately ousted a new female that had already paired with the last year's male.

An adult female Black Kite furnished inverse results so far as the length of migration was concerned. This bird nesting in Thuringia in central Germany, fitted with a solar-powered PTT on 16 June 2002, has to date yielded several thousand Doppler fixes. Six winterings, mainly in southern Mauritania, and twelve migration routes have been thoroughly documented. Each year it has migrated far more rapidly in autumn - the fastest taking only 17 days (averaging 332 km per day) - than in spring.